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Features of the calculation of heat losses through the filling of window openings

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Abstract. The article is devoted to the calculation of heat losses through the filling of a horse aperture. The scheme of formation of the “cold bridge” through the filling of the window opening was presented. Two window designs were calculated and analysed using numerical simulation. It was calculated to reduce the cost of the project by changing the constructive solution. The article examined various ways to take into account the position of the window opening when calculating heat losses. A formula was proposed for the correct calculation of heat losses through the filling of a window opening. Separately highlighted issues that need to be considered in further research.

1. Introduction

In connection with the depletion of natural energy reserves, the urgency of the problem of saving fuel and energy resources and improving the energy efficiency of buildings increases. To solve this problem, it is necessary to conduct various energy-saving measures: the use of effective and environmentally friendly thermal insulation materials; the use of energy efficient, reliable and durable enclosing structures, reducing heat loss; improving the quality of thermal design of buildings.

Full calculations of the values of reduced resistance to heat transfer of structures, coefficients of heat engineering uniformity, temperatures on the inner surface of the building envelope when designing buildings should be performed based on the calculation of temperature fields. The need of this kind is primarily related to ensuring the safety of the building, preventing freezing, moisture, mold on the inner surface of the enclosing structure in the area of heat-conducting inclusions (exterior corners, joints, window slopes), as well as reduce heat loss through these places. Calculations of temperature fields help to avoid thermal defects in advance (at the design stage).

The computational methods developed decades ago need adjustments that will make them more adapted to variant design solutions. Modern calculation programs that are continually developed, allow to do it.

The development of programs for engineering and scientific calculations allows for more detailed calculations using existing engineering calculation methods. In this material, the ANSYS Steady State Thermal design complex will be used to determine heat losses through the wall with a window opening in the living room.

Determining the heat losses of the premises of any building is the basis for the selection of heating equipment and the calculation of the required power of the heating system, which affects the design solutions for outdoor heating networks. Consequently, the set of subsequent decisions that affect the total cost of the project depends on the accuracy of calculating the heat loss of the building.



This article analyzes the results of the thermal analysis of two design options for installing a window opening.

2. Features of the calculation of heat loss

The given resistance to heat transfer of the window opening in the method of determining heat losses through external enclosing structures is taken according to the thermal calculation [2, app. E] or based on the results of field tests in an accredited laboratory [2, app. K]. On the basis of calculations and field tests conducted by manufacturers of window units, tables of reduced resistances to heat transfer of fillings of window openings were compiled, which, in most cases, designers use. However, these tables do not take into account the various ways of installing a window opening in the wall structure. In fact, this factor will affect the actual amount of heat loss of the room.

If the filling of the window opening begins to shift towards the inner surface of the wall so that between the window and thermal insulation from the outside air a part of the supporting wall of the wall protrudes (Fig. 1), the heat loss of the room to be calculated will increase due to the appearance of a "cold bridge". Moreover, if the window cover will be partially shifted towards the thermal insulation of the outer wall, on the contrary, the heat loss will be less.

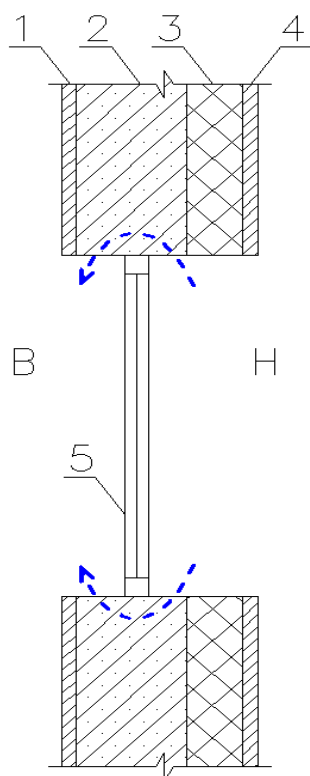


Figure 1. Scheme formation of "cold bridge"
Notation: 1 - internal finishing; 2 - wall bearing layer; 3 - thermal insulation; 4 - outer finishing layer; 5 - window cover; B - internal air; H - outside air.

In order to assess the influence of the installation method of filling the window opening on the total heat loss through the outer wall of the calculated room, we will perform a numerical calculation in ANSYS Steady State Thermal for two options for the location of the window cover (Fig. 2 and 3). In the first version, the outer border of the window sash is overlapped with thermal insulation, while in the second it is offset by 50 mm towards the outside air. Both installation options are allowed. The difference in the cost of mounting these options is practically absent.

The calculation was performed for the climatological data of the city of Yekaterinburg for a living room with an outer wall of 6.0 x 3.3 m and one window opening. Outdoor temperature is -32°C [1]. The calculated grid of models was built in ANSYS Meshing. A stationary process was considered.

The temperature fields obtained as a result of numerical calculation of the models are presented in Fig. 4 and 5.

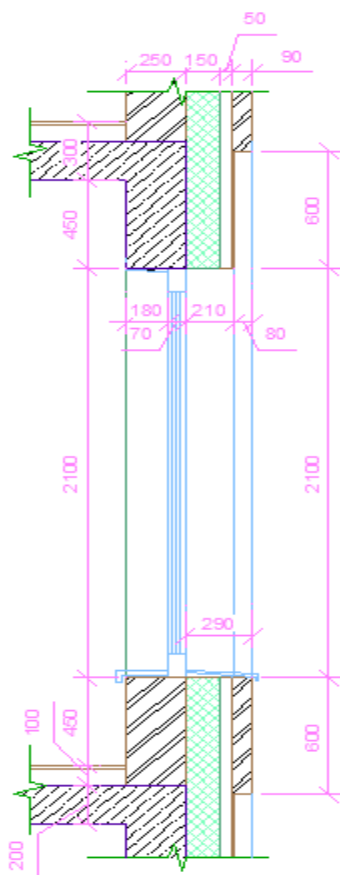


Figure 2. Option №1 install window sash.

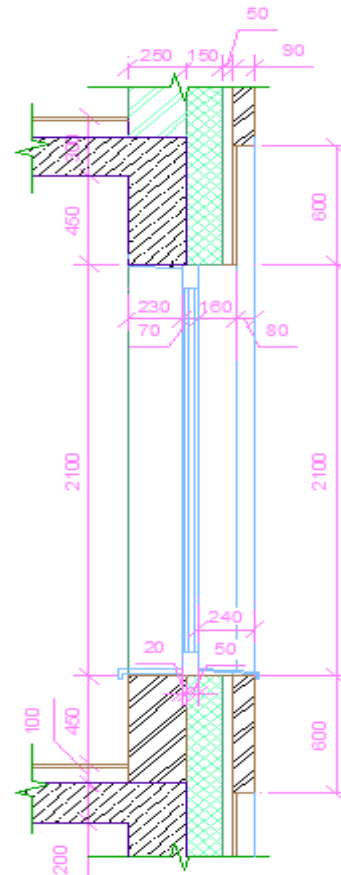


Figure 3. Option №2 install window sash.

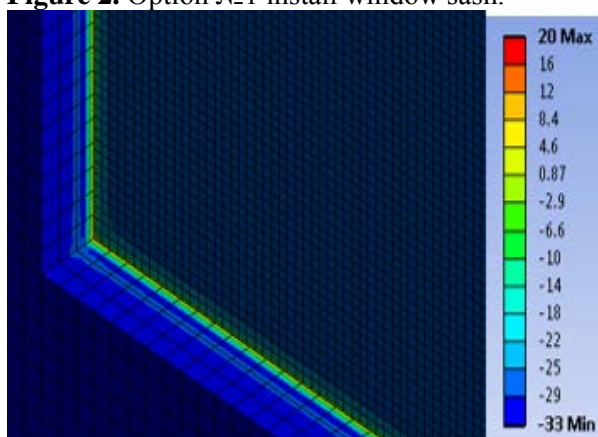


Figure 4. Temperature fields of the window from the outside (option № 1).

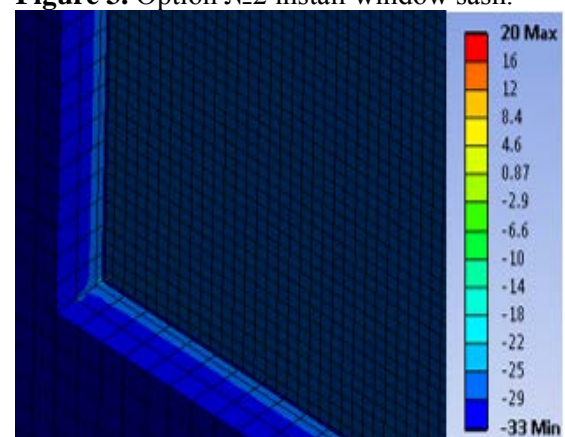


Figure 5. Temperature fields of the window from the outside (option №2).

The calculation in the program showed that the heat loss through the outer wall for the first option is 870 W, and for the second - 730 W. When determining the heat loss using the standard “manual” calculation method, the result is 850 W. The value of heat loss for the first option, obtained in the

design program, is close to the value of 850 W. However, when you change the position of the window sash in the opening in the second version, heat loss is reduced by as much as 120 watts.

Let us analyze what this calculation result means. This outer wall construction is taken from the project of a 25-storey residential house under construction. On one floor there are ten windows of this design. Under each window is installed one sectional steel radiator. Reducing the heat output of a sectional heater by 120 W (by about 8-9%) will lead to a decrease in the number of sections by at least one. That is, the total number of sections of all radiators will be reduced by 250 pieces. This will mean significant savings for the developer. In addition, such a reduction in the calculated power of the heating devices will lead to a certain decrease in the diameters of the heating system pipelines. In addition, the selection of equipment for individual heat point will be carried out for a load of less than 30 kW (25 floors \times 10 devices \times 120 W = 30 kW) because of this unaccounted factor.

Therefore, the location of the filling of the window opening in the construction of the opening must be taken into account in the calculation of heat losses. The current rules provide for the calculation, which is based on the calculation of temperature fields[2, app. H]. But this method is rather complicated for an ordinary designer who is not familiar with the calculation in complex engineering software systems, such as ANSYS. In addition, it seems irrational every time to make calculations of this kind, when most of the designs of the exterior walls of residential buildings are similar.

In addition, a set of rules [3] allows solving this problem. But this solution will be incorrect, since this linear heterogeneity will be taken into account in the construction of the wall, and not the window. That is, heat losses will be determined incorrectly in rooms with a large number of windows and in rooms without them. Also, this method is quite time-consuming, because the designer for the calculation will have to determine the total length of all the window slopes on the facade. Because of these shortcomings, it is not rational to use this set of rules in this case.

The actual heat transfer resistance of filling the window opening will be most easily determined by the following formula:

$$R_{fact}^w = R_{red}^w \cdot m \quad (1)$$

R_{fact}^w – actual resistance to heat transfer filling the window opening, $\frac{m^2 \cdot ^\circ C}{W}$;

R_{red}^w – reduced resistance to heat transfer filling the window opening, $\frac{m^2 \cdot ^\circ C}{W}$;

m – correction factor that takes into account the position of filling the window opening in the thickness of the wall.

The correction factor in the formula (1) can be determined by calculations in engineering programs, or by field tests in accredited laboratories. It can be set for each specific position of the window sash, or it can be a function of its actual displacement from a certain standard position.

This method allows the designer to take into account each window in the calculation of heat loss separately and correctly determine the load on the heating for each room.

3. Current issues

This paper leaves a number of questions, the solution of which will lead to an improvement in the quality of design:

- 1) How to take into account the influence of the position of filling the window opening in the wall on the value of its resistance to heat transfer?
- 2) What will be the economic effect of a more detailed calculation of the required capacity of the heating system of the building?
- 3) How does the filling position of the window opening affect the amount of infiltration of outside air into the room?
- 4) How can I optimize the filling position of the window opening in the wall structure?

4. Conclusion

This article analyzes the results of the heat engineering calculation of two design options for installing a window opening in a wall. The calculation methods used do not take into account this factor. According to the results of numerical calculations revealed a significant difference in heat loss of the room for these options. This nuance significantly affects the cost of the project. The position of filling the window opening in the wall construction must be considered when calculating. The resulted algorithm of calculation of an ejection stream will allow making exact selection of the ventilating equipment for the accepted technical decision.

There are several open problems associated with the correction factor in the proposed formula. It is important to choose in what form its presentation will be: in the form of a function, in the form of a table or in another form. In addition, in the future it is necessary to conduct laboratory tests for various types of window constructions in order to determine the values of this coefficient.

Improving the quality of building design allows us to save significant amounts of energy resources. That is why it is impossible to neglect the possibility of computer modeling in building construction processes.

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